Device for on-site checking, device for characterization and method of checking an angle-of-attack probe

BACKGROUND OF THE INVENTION

The invention pertains to an on-site checking device, to a characterization device and to a method of checking a mobile angle-of-attack probe for example mounted on the skin of an aircraft. It will be possible to generalize the term "angle-of-attack probe" for any mobile member making it possible to measure the angle of attack of the air with respect to the skin of the aircraft, such as for example a mobile multifunction probe comprising, in addition to the determination of angle of attack, pressure taps making it possible for example to determine the total pressure and the static pressure of the air surrounding the aircraft.

An angle-of-attack probe is a device for measuring the orientation of the wind. The invention finds its application more particularly in the aeronautical industry, where the adjustment of an angle-of-attack probe has vital importance. Specifically, the value of the measurement of the orientation of the apparent wind of an aircraft makes it possible to obtain, after calculation, the value of the angle of attack and lift parameters. These two parameters must be known reliably since they make it possible to ensure optimal flight conditions, but above all they are critical parameters for flight safety. The devices and the method of the invention may nevertheless be used in other fields, in particular in meteorology. Wind vanes installed on meteorological stations are akin to angle-of-attack probes and must also be regularly adjusted, or even changed.

An angle-of-attack probe is a member, part of which is situated outside the aircraft. This external part is subjected to climatic variations, in particular to

temperature variations. Moreover, it may be impaired by impacts with external bodies, such as birds, grains of sands or particles of ice. More generally, it may be worn through by external forces which may be applied to it. The conditions outside an aircraft are very harsh. The part of the angle-of-attack probe directly sensitive to the wind is fragile. Forces applied to this device in the flight phase are very strong. These forces may moreover modify the adjustment of the part sensitive to the wind with respect to orientation sensors to which it is linked.

For economic reasons, when the angle-of-attack probe has to be replaced, only a limited part of the latter is replaced. An angle-of-attack probe thus comprises a wind vane that can move in the wind, a support for sensors and a probe body. Sometimes only the wind vane is changed. The fixing of a new wind vane to a support for sensors and to a probe body already in place, or the fixing of a new wind vane and of a sensor support to a probe body already in place must then be undertaken. In this case there is a need for on-site adjustment of the orientation sensors with respect to the probe body, as a function of the new angle-of-attack probe thus made.

Additionally, airlines impose frequent monitoring of the adjustments of angle-of-attack probes. This monitoring may sometimes culminate in the observation of drifts, and hence lead to a new adjustment of the angle-of-attack probe. It therefore appears to be necessary to implement a reliable and cheap procedure for adjusting the angle-of-attack probe.

The most accurate adjustment procedure requires adjusting the wind vane by means of entry into a wind tunnel. Specifically, the wind tunnel makes it possible to create a wind of perfectly known orientation. A complete angle-of-attack probe is then adjusted directly as a function of the orientation of the wind

provided by the wind tunnel. Under these conditions a complete angle-of-attack probe placed on the aircraft is perfectly adjusted. The adjustment is carried out by fixing the wind vane in a known position with respect to the probe body, and by mechanically adjusting the position of the sensors support with respect to this probe body, so that a signal delivered by the sensors in the known position of the wind vane equals an expected value.

In the state of the art, the placement of the wind vane in a known position with respect to the probe body requires the existence and the material identification on the wind vane, of a marker corresponding to an aerodynamic zero. The aerodynamic zero is observed in the wind tunnel. It corresponds to an orientation of the wind vane along the axis of the wind of the wind tunnel, and to a corresponding position of the sensors support, which in this case gives an expected measurement signal (in general a zero signal). For this aerodynamic zero, the relative positions of the wind vane with respect to the sensors support are marked definitively. In practice this marker is obtained by marking the wind vane with respect to the probe body, and by also marking the sensors support with respect to the probe body. The aerodynamic zero is identified for example by a hole, made in the factory, in the wind vane.

The principle of adjustment, in the state of the art, is to lock the hole representing the aerodynamic zero in a known position with respect to the probe body, and to place the orientation sensor, with respect to this locked assembly, in a position such that the measurement signal delivered is the expected measurement signal (in general the zero signal). The operation of determining the aerodynamic zero carried out in a wind tunnel is called characterization of the angle-of-attack probe.

Figure 1, placed at the end of the present description, diagrammatically illustrates the general structure of an angle-of-attack probe 10.

The angle-of-attack probe 10 comprises a probe body 11 consisting of a casing, generally cylindrical, closed on its upper part by a plate 12, advantageously circular. A wind vane 13 comprises a mount 14, of small thickness and movable about an axis Δ_s, that is also called the probe axis. The wind vane 13 also comprises a blade 15 atop the mount 14. The blade 15 is intended to orient itself in the wind surrounding the angle-of-attack probe 10.

The shape and the profile of the cross section of this blade 15 are determined by the ultimate application of the probe, that is to say essentially the type of aircraft for which it is intended, the degree of accuracy of the angle measurements to be obtained and a certain number of physical parameters describing the environmental conditions to which the angle-of-attack probe is subjected: maximum speed obtained by the aircraft, hence also of the air flowing along the walls of the fuselage, maximum variations of temperatures, etc. These considerations are outside the particular scope of the invention. Specifically, the positioning device which is the subject of the invention, and this is one of its advantages, remains compatible with all types of blade-based probes of the prior art and requires no modification, neither structural nor functional.

The casing encloses in particular a sensor of angle of rotation of the wind vane 13, and more precisely of the blade 15, about the axis Δ_s with respect to the probe body 11. The latter may call upon a measurement based on the use of a potentiometer whose axis is driven by the rotation of the blade 15, of a sensor of the so-called "resolver" type or of any other sensor of the prior art appropriate to this field of application. The

amplitude of the rotation of the wind vane 13 about the axis Δ_s is converted into electrical signals, transmitted by links 16 to a signal processing apparatus (not represented) situated inside the aircraft, generally in the cockpit, so as ultimately to be displayed there on an onboard instrument in an appropriate form, depending on the parameters measured.

The probe body 11 is disposed in an orifice (not represented) provided for this purpose in the fuselage of the aircraft and covered with a shroud (not represented) in such a way that what is called the aircraft's "skin", referenced PA, is flush with the upper surface of the mount 14 of the wind vane 13. It is in fact necessary that, with the exception of the protuberance formed by the blade 15, no asperity should remain that might disturb the flow of the air streams outside the skin PA.

The angle-of-attack probe 10 comprises means of positioning with respect to the skin PA of the aircraft. The means of positioning comprise for example two lugs 17 and 18 intended to engage in corresponding holes made in the skin PA. A straight line Δ_v concurrent with the axis Δ_s passes through the lugs 17 and 18.

It is readily understood that, during periodic operations of routine monitoring and servicing, airlines want to be able to test the proper operation and certify the precision of the measurement signals provided by the angle-of-attack probes, if possible without having to dismantle them, that is to say remove them, extract them from their housing, then refit them after testing, which would give rise to lengthy and expensive operations. Furthermore, it should be recalled, on the one hand, that the required accuracy of the measurements is very high: typically a few tenths of a degree, and that on the other hand, the environmental conditions to which the angle-of-attack

probes are subjected are extreme. Should it be necessary to dismantle the angle-of-attack probe, it is desirable to avoid recourse to a wind tunnel for testing or adjusting the angle-of-attack probe by using an on-site gauging bench as far as possible. The on-site gauging bench is used at the foot of the aircraft, that is to say after removing the angle-of-attack probe from the aircraft.

In the patent application filed under number FR 98 16353 a bench is described for factory gauging of an angle-of-attack probe comprising a wind vane. This bench uses a point-like mechanical reference against which the mobile blade of the probe is rested. The factory gauging bench makes it possible to carry out the characterization of the angle-of-attack probe. More precisely, the factory gauging bench makes it possible to determine a deviation between angular orientation of the mobile blade between a first position where it is resting against the point-like mechanical reference and a second position where it is oriented freely with respect to a known directional wind obtained through a wind tunnel.

The patent application filed under number FR 98 16353 also describes an on-site gauging bench identical to the factory gauging bench and making it possible to adjust the position of the orientation sensor of the wind vane as a function of the angular deviation defined during characterization.

Additionally, in the patent application filed under number FR 99 16773 a device is described for in-situ angular positioning of an angle-of-attack probe comprising a wind vane. This device comprises an enveloping structure intended to receive the mobile blade of the wind vane. The in-situ positioning device is used when the angle-of-attack probe is mounted on the skin PA of the aircraft. The in-situ positioning device makes it possible to check the linearity of the

orientation sensor and make it possible to obtain accuracy of the order of a degree in the adjustment of the zero of the sensor. Better accuracy cannot be obtained since the mechanical reference of the in-situ positioning device is different from the mechanical reference of the on-site gauging bench or of the factory gauging bench.

SUMMARY OF THE INVENTION

The invention makes it possible to solve this problem by using a single mechanical reference for the three operations described above, namely the factory characterization, the checking of the probe on site, at the foot of the aircraft and the angular adjustment of the probe mounted on the aircraft.

Accordingly the subject of the invention is a device for on-site checking of an angle-of-attack probe, the probe comprising a probe body, a mobile blade rotatable about an axis with respect to the probe body, characterized in that it furthermore comprises an enveloping structure intended to receive the blade, the blade being immobilizable temporarily with respect to the enveloping structure, and means of measuring an angle of the enveloping structure with respect to the probe body.

The subject of the invention is also a method of on-site checking of an angle-of-attack probe, the probe comprising a probe body, a mobile blade rotatable about an axis with respect to a probe body and a sensor of angle of rotation of the blade with respect to the probe body about the axis, characterized in that the device furthermore comprises an enveloping structure intended to receive the blade, the blade being immobilizable temporarily with respect to the enveloping structure, and means of measuring an angle of the enveloping structure with respect to the probe body, and in that the method consists in:

- immobilizing the probe body with respect to a support of the device,

- immobilizing the blade in the enveloping structure,

- orienting the blade in such a way that the means of measuring an angle of the enveloping structure with respect to the probe body indicates an angle of characterization of the probe,

- adjusting the angle-of-rotation sensor so that it indicates a zero value.

A further subject of the invention is a device for characterizing an angle-of-attack probe, the probe comprising a mobile blade rotatable about an axis, characterized in that the device comprises an enveloping structure intended to receive the blade, and in that the enveloping structure forms a mechanical reference in the determination of an angle of characterization of the probe.

BRIEF DESCRIPTION OF THE DRAWING

The invention will be better understood and other advantages will become apparent on reading the detailed description of an embodiment given by way of example and illustrated by the appended drawing in which:

- figure 1 represents an exemplary embodiment of an angle-of-attack probe for aircraft of the type comprising a mobile wind vane movable about an axis; figure 1 was described earlier to present the invention;

- figure 2 represents a device for characterization or device for on-site checking of an angle-of-attack probe comprising an inclinometer oriented perpendicularly to the axis of rotation of the wind vane;

- figure 3 represents the device of figure 2, in which the inclinometer is oriented parallel to the axis of rotation of the wind vane.

For better comprehension, the same elements will bear the same reference marks in the various figures.

DETAILED DESCRIPTION OF THE PREFERED EMBODIMENT

Represented in figure 2 are the common elements of a device for characterization and of a device for on-site checking of an angle-of-attack probe. The characterization device is used in a wind tunnel and comprises means for positioning itself in the wind tunnel. These means are not represented in figure 2. The on-site checking device is used at the foot of the aircraft. More precisely, when an angle-of-attack probe is to be checked, it is removed from the aircraft then placed temporarily on the on-site checking device situated in proximity to the aircraft. The on-site checking device makes it possible to check and adjust the angle-of-attack probe without requiring recourse to a wind tunnel.

The device represented in figure 2 comprises a support 20 having the form of a right-angled bracket. The support 20 has considerable rigidity so as not to deform during the various operations required for checking the probe. The support 20 comprises a first horizontal flange 21 and a second vertical flange 22. The device can comprise adjusting screws 23 and 24 as well as a spirit level 25 so as to adjust, when mounting the angle-of-attack probe on the support 20, the verticality of the straight line Δ_v defined with the aid of figure 1.

The second flange 22 comprises means for immobilizing the probe body 11 on the flange 22 in such a way that the probe axis Δ_s is in a horizontal position. These means comprise for example a circular orifice drilled in the flange 22 and similar to that made in the skin PA of the aircraft as well as means of fixing the probe body 11 to the flange 22. The means for immobilizing the probe body 11 on the flange 22 furthermore comprise

holes intended to receive the lugs 17 and 18. These holes are similar to those made in the skin PA of the aircraft to position the angle-of-attack probe when the latter is mounted on the aircraft.

The device furthermore comprises an enveloping structure 26 intended to receive the blade 15 of the angle-of-attack probe 10. The enveloping structure 26 comprises for example two half-shells 27 and 28 between which the blade 15 is immobilized temporarily. Other exemplary embodiments of an enveloping structure are described in the patent application filed under number FR 99 16773.

The device comprises means of measuring an angle of the enveloping structure 26 with respect to the probe body 11. In figure 2, the angle of the enveloping structure 26 with respect to the probe body 11 is an angle of rotation of the blade 15 about its axis of rotation Δ_s.

The means of measurement may comprise an index 30 integral with the enveloping structure 26 and a graduated angular sector 31 integral with the support 20. The index 30 moves in rotation about the axis Δ_s with the enveloping structure 26 and consequently makes it possible to visualize the angular position of the blade 15 about its axis of rotation Δ_s. The index 30 moves in front of the graduated angular sector 31 which may be embodied directly on the flange 22.

Advantageously, the means of measuring an angle of the enveloping structure 26 with respect to the probe body 11 comprise an inclinometer 29 integral with the enveloping structure 26. The inclinometer 29, can replace the index 30 and the graduated sector 31, integral with the enveloping structure 26. In figure 2, the inclinometer 29 is oriented in such a way as to measure an angle of rotation of the blade 15 about its axis of rotation Δ_s.

During on-site checking of an angle-of-attack probe 10, the following procedure is carried out:

- the probe body 11 is immobilized with respect to a support 20 of the device,
- the blade 15 is immobilized in the enveloping structure 26,
- the blade 15 is oriented in such a way that the means of measuring an angle of the enveloping structure 26 with respect to the probe body 11 indicates an angle of characterization of the probe,
- the angle-of-rotation sensor is adjusted so that it indicates a zero value.

Advantageously, the device comprises means of immobilization of the enveloping structure 26 with respect to the support 20. These means may use the index 30 that is latched in position with respect to the graduated sector 31. These means of immobilization make it possible to immobilize the enveloping structure 26 with respect to the support 20 after having oriented the blade 15 in such a way that the means of measuring an angle of the enveloping structure 26 with respect to the probe body 11 indicates an angle of characterization of the probe, and before adjusting the angle-of-rotation sensor so that it indicates a zero value.

In figure 3, the angle of the enveloping structure 26 with respect to the probe body 11 is an angle of rotation of the blade 15 measured in a plane containing the axis Δ_s. More precisely, an inclinometer, integral with the enveloping structure 26, is oriented in such a way as to measure the angle of the enveloping structure 26 with respect to the probe body 11 in a plane containing the axis of rotation Δ_s. The inclinometer, oriented in this way, bears the reference mark 35. This orientation of the inclinometer 35 makes it possible to measure the angle between the axis of rotation Δ_s and the plane of symmetry of the blade 15. Stated otherwise, the inclinometer 35 makes it possible to

verify whether the blade 15 has been twisted during the use of the angle-of-attack probe with respect to its original position. By using the enveloping structure 26 as mechanical reference in the angle measurement carried out by the device it is possible, by placing the inclinometer 35 as represented in figure 2, to verify any deformation of the blade 15 with respect to the mount 14.

A device for characterizing an aircraft angle-of-attack probe is similar to a device for on-site checking of the same angle-of-attack probe 10. The characterization device comprises an enveloping structure intended to receive the blade and the enveloping structure forms a mechanical reference in the determination of the angles of characterization of the probe.

It is possible to use the same inclinometer to perform the angle measurement perpendicularly to the axis Δ_s and the angle measurement in a plane containing the axis Δ_s. Nevertheless, the commercially available inclinometers are relatively inexpensive to buy. To avoid having to modify the orientation of a single inclinometer, it is advantageous to mount, integral with the enveloping structure 26, two inclinometers 29 and 35, the first 29 with the orientation represented in figure 1 and the second 35 with the orientation represented in figure 2.

Stated otherwise, the means of measuring an angle of the enveloping structure 26 with respect to the probe body 11 comprise two inclinometers 29 and 35 integral with the enveloping structure 26. The first inclinometer 29 makes it possible to measure an angle of rotation of the blade 15 about its axis of rotation Δ_s and the second inclinometer 35 makes it possible to measure an angle of rotation of the blade 15 measured in a plane containing the axis Δ_s.

Their respective position relative to the enveloping structure 26 is then fixed thereby simplifying the use of the checking device.

When envisaging the use of the checking device on board an aircraft carrier for adjusting the angle-of-attack probes of aircraft carried on board, the support 20 is apt to move in tempo with the aircraft carrier and the inclinometer or inclinometers 29 and 35 will not give stable measurements. To alleviate this problem, one or two additional inclinometers are advantageously disposed on the device. The means of measuring an angle of the enveloping structure 26 with respect to the probe body 11 then comprise one or two inclinometers 36 and 32 integral with the support 20. The angle of rotation of the blade 15 about its axis of rotation Δ_s is obtained by differencing the measurement carried out by the first inclinometer 29 integral with the enveloping structure 26 and the first inclinometer 31 integral with the support 20. The angle of rotation of the blade 15 measured in a plane containing the axis Δ_s is obtained by differencing the measurement carried out by the second inclinometer 35 integral with the enveloping structure 26 and the second inclinometer 32 integral with the support 20.

The use of four inclinometers on the device makes it possible to avoid having to adjust the screws 23 and 24 even when the device is used on dry land.